# THE PROGRESSIVE FISH CULTURIST

NEWS AND VIEWS FROM MANY SOURCES ON PRACTICAL HATCHERY PROBLEMS

ISSUED BY THE

U. S. DEPARTMENT OF COMMERCE
DANIEL C. ROPER, SECRETARY

BUREAU OF FISHERIES
FRANK T. BELL, COMMISSIONER

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## THE PROGRESSIVE FISH CULTURIST

A SERIAL memorandum published occasionally for the advancement of Federal, State, and private fish culture and fishery management in fresh waters.



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BUREAU OF FISHERIES, U. S. DEPARTMENT OF COMMERCE

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# FISH MANAGEMENT IN THE PISGAH NATIONAL GAME PRESERVE

By William M. Keil,
U. S. Forest Service

HIGH AMONG the peaks of the Appalachian Range in Western North Carolina, and adjacent to the Great Smoky National Park, lies the 900,000 acre Pisgah national Forest. Approximately 100,000 acres of this area was set aside in 1916 by State and Federal action and is known as the Pisgah National Game Preserve. This rather heavily forested territory includes the headwaters of the North Fork of the French Broad, Davidson, North and South Mills, and Pigeon Rivers, and constitutes a wild life unit particularly favorable for fish and game management. Under careful Federal administration and protection, both large and small game have increased to a most satisfactory extent, but despite 20 years of what was reported to be systematic fish planting, the streams have continued to become more and more depleted each season.

During the winter of 1934, through a cooperative agreement between the U. S. Bureau of Fisheries and the Forest Service, a four step program was instituted through which it was hoped really worthwhile trout fishing might be built up and maintained. These steps provided for a preliminary survey of the physical, biological, and thermal conditions of the waters to be considered; a stream improvement project in which the physical characteristics were to be restored to as nearly approaching their original conditions as possible; an initial fish planting program based upon the findings of the survey and the extent and character of the improvement

work; and finally, a regular and systematic checking-up through research of the results accomplished, so that a more permanent policy might be adopted regarding the numbers, sizes, and species of fishes to be planted and the amount of public angling thought justified under careful regulations.

The first and second steps - surveys and improvement work - were undertaken and completed so far as possible during the seasons of 1934, 1935, and 1936. Considerable readjustment of the original plan was found necessary due to the activities of the CCC camps in constructing many new roads and trails throughout the Preserve. Streams that formerly ran clear after the heaviest precipitation, became badly discolored even under rather light rainfall. Wash from the raw cuts and highway fills was deposited in the newly created pools, and riffle areas became coated with mud and pulverized road material. It was plainly evident that the original survey would be of little value in determining the carrying capacities of the streams under such marked changes, so a new set-up was inaugurated in which regular examinations are made of the bottom food organisms, thermal, gas, and chemical conditions. It also became necessary to rearrange the types of pool construction in many of the streams, to prevent excessive accumulation of silt with consequent destruction of their value as environmental assets.

Tremendous boulders sometimes many tons in weight were placed in position in such pools to provide natural looking deflectors and prevent much of this silt from settling. To prevent a continuance of erosion from these newly constructed roads, and hasten the revegetation of the unsightly cuts and fills, a carefully planned and supervised program of roadside improvement was carried out by the Forest Service. This is already showing its beneficial effects on the life of the streams.

In the general plan of all fish management programs, the primary objective is to demonstrate the value of scientific management as a means of improving the angling conditions. In this particular Pisgah project the main objective is separated into a number of secondary objectives for which the climatic, geographical, and water conditions are exceptionally favorable for conducting observations and studies. The district has one of the heaviest rainfalls in the United States. This precipitation is normally regular throughout the season. The comparatively short, mild winters allow a long growing season for the fish, and opportunities for stream collections and studies of fish and fish food organisms that are not possible in more more northern sections. The waters are extremely soft, slightly on the acid side, and seldom below the situration point in dissolved oxygen.

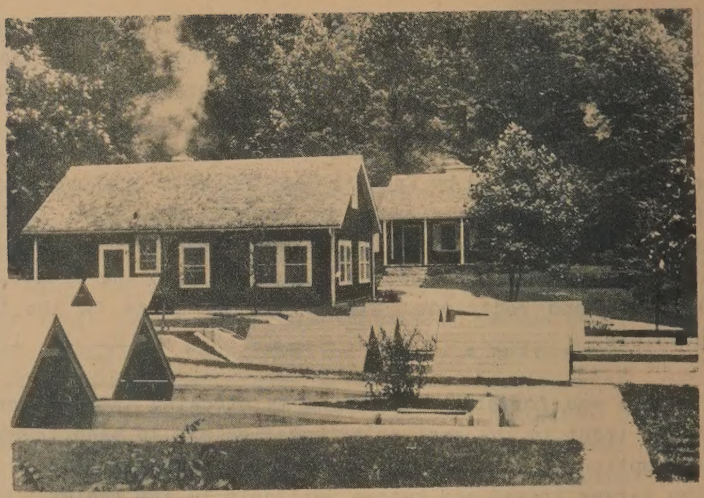
The secondary objectives for which it is thought this area might prove a fruitful field for investigation are as follows: To determine the maximum stream temperatures to which brook trout may be subjected and still remain in good condition and active on the hook; to study and record the extent to which both brook and rainbow trout in the various sizes and ages migrate downstream when planted in the higher and smaller tributaries; to determine the stocking intensities of trout of various sizes that will produce the most satisfactory results, and the best methods of planting fish and regulating fishing to secure the maximum results for the angling public; to discover

the types of foods utilized by planted fish, and the relationship of bottom and drift organisms to production of fish; and the study of the effect of so-called stream improvement on production of trout and bottom food organisms.

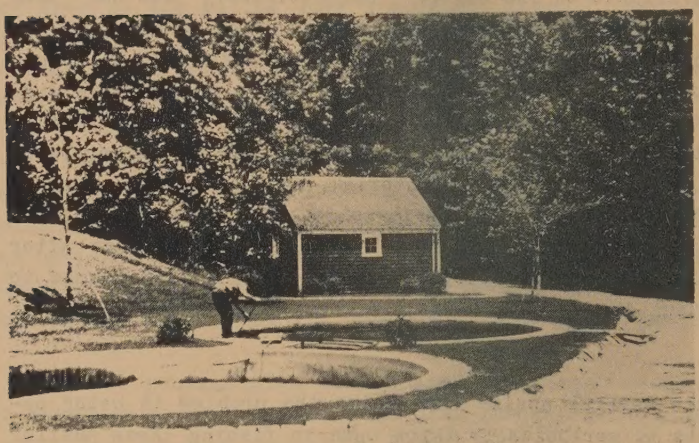
For experimental purposes this area has additional advantages in that it is regularly patrolled by Federal Game Wardens; that streams can be kept closed or opened for whatever length of time is thought desirable; that the number of anglers permitted to fish on certain dates or during the open season can be regulated; and that each angler must be checked in and out of the Preserve so that his catch may be examined and recorded. There are few areas in the United States where this is possible.

It was formerly the custom in stocking these waters to plant both rainbow and brook trout in the smaller tributaries and to keep these closed to fishing, with the assumption that as the trout reached a certain size or age they would drop down to the larger treams and become available to the angler. Unquestionably this has been true of the rainbow in this territory, but the comparatively few brook trout as against rainbows taken when only the larger streams were opened to fishing, would indicate the opposite for brook trout. Based upon scale examinations and other significant observations, studies are being made to determine whether this disinclination of the brook trout to migrate downstream is due to the lower water temperatures usually prevailing in these higher and smaller tributaries, or to a natural preference for waters of this size and character. If the investigations disclose that the majority of the brook trout do permanently remain in these smaller streams after reaching the adult stages, then it must be determined which is the best course to pursue in planting and regulating the fishing to secure the maximum results for the angler's basket.

In this relation there are several angles from which the problem is being approached. Will it be advisable to periodically throw open to fishing these smaller tributaries in order that the mature brook trout may be removed, with the knowledge that by so doing large numbers of undersized rainbows will also be hooked and perhaps permanently injured? Or will it be preferable to select certain of these streams in which the food and water conditions are favorable for brook trout, and set these aside as exclusive brook trout waters and restrict all future plantings to this species? Will the numbers of brook trout that such a policy might provide the angling public outweigh the value of such tributaries as sanctuaries for rainbows in the pre-migratory stages? If subsequent investigations show conclusively that the percentage of brook trout retaken by anglers when planted in equal number are disproportionate to those for rainbows, should the rearing and planting of brook trout be discontinued in this experimental area of the Preserve? Both species do well in these waters, and many anglers prefer the brook to the rainbow trout. Can good fishing for both species in the same waters be built up and maintained by rearing the fish to larger sizes, and planting them directly into the fishing streams, rather than relying as formerly on a possible drift down from the smaller tributaries? These matters can only be determined by painstaking investigations over a considerable period of time, so the initial stocking program that has been set up is sufficiently



Trout rearing station on the Davidson River, Pisgah Forest, North Carolina.



Circular rearing pools at the Pisgah Forest Station.

Method of shading raceways at the rearing station. (U. S. Forest Service Photo, by Clint Davis.)

Keil and Chamberlain transferring fish from live box in stream to pack cans for planting in the Pisgah Preserve.

Planting crew using pack cans.

Planting fish under Keil's watchful eye.
(U. S. Forest Service Photos, by Clint Davis.)

flexible to permit of seasanable changes being made.

From the investigations carried out during 1935-36, when attempts were made to carry out a stocking schedule with fish brought in from distant hatcheries, it became clearly evident that if successful fish management was to be practiced in this territory some provision must be made for rearing locally the numbers, sizes, and varieties of trout requisite for the stocking policy. Under a new agreement between the Bureau of Fisheries and the Forest Service, a modern trout rearing station was designed, constructed, and fully equipped for fish cultural work by the Forest Service, and turned over to the Bureau for operation. The site selected is at the head of the Davidson River, and the location so situated as to be easily accessible to all of the waters under management. The Rearing Station consists of 18 circular and rectangular concrete pools of various sizes, supplied through a 10 inch pipe line with 2,000 gallons of water per minute. A concrete dam and protected intake box at a point upstream where the channel and banks are composed of solid bed rock insures the water supply against any possible washout during the most severe flood stages. The buildings at the station consist of a standard Forest Service four rooms and bath cottage; 1 two-car garage; generator house equipped with automatic 2500 watt lighting plant, and a combination work shop with storage, refrigeration, and feed roooms, and a research laboratory.

With the completion of the Rearing Station in March 1917, the Bureau of Fisheries transferred from the Leetown, W. Va. Station, Reuben O. Knuth to take charge of the fish cultural work. Some months previously, Thomas K. Chamberlain had been detailed to this district to carry out biological research in both field and laboratory.

Approximately 75,000 small fingerling brook, brown, and rainbow trout were transferred by truck and railway fish car from the Bureau's stations at Leetown, W. Va., and Wytheville, Va. The bulk of these fish were received as No. 2 fingerlings the middle of May, and so remarkable were the results in rearing these trout, that by the first of September over 40,000 were available for planting as 6 to 8 inch fish. In this connection it might not be out of place to mention that in almost 40 years of direct association with fish cultural work, the writer has never previously seen a finer or healthier lot of trout than these. These results were unquestionably attributable to the unusual care in providing plenty of room, ample circulation of water through the pools, regular and sufficient amounts of nourishing food, frequent and close grading, and cleanliness of surroundings. The rather high water temperatures also contributed toward the rapid growth, and under less careful cultural practices might have resulted disastrously. During July and August, the water temperatures in the pools ranged from 58 degrees in the early morning to an occasional 70 degrees towards evening. Under these temperatures, however, the brook trout appeared to thrive as well as did the brown and rainbow trout. The foods supplied to these fish were beef hearts and sheep livers combined with about one-third of either salmon carcass or seal meal.

In working out a stocking program for the waters under management, it had been decided that approximately 48,000 fish were needed for the first season's planting.

As set up in the plan, none of these were to be less than 6 inches in length. It was naturally assumed that it would be at least late fall before planting with this sized fish could begin, and that possibly a part of the brown trout might have to be carried over into the yearling stages. However, with the rapid growth made by all of these fish, the stocking program got under way the first of September with the planting of 7 inch brook trout. It continued daily until the last of October when the full quota of brook, brown, and rainbow had been released into the designated waters.

It was no little problem to plant this number of good-sized fish in a country of this character. In order to do so, every detail had to be worked out so that no hitch would occur at either end or in the middle. Each of the streams was divided into planting sections, and at points on the highways that were most accessible to these sections, trails were brushed out so that the fish from a particular truck load could be quickly carried by the planting crew to a live box in the stream and from which they were to be scattered. After resting the fish for a while in this live box, they were transferred to the special Adirondack type pack cans, and the planting crew following the stream channel as closely as possible, scattered the fish a few in a place until the section was covered. The light, easily portable cage or live box was then removed from the stream and taken to the next planting section in readiness for the following load. On certain streams that were only accessible at one point by truck, the fish had to be carried by pack can for distances of seven and eight miles to reach the sections to be planted. While the actual packing of the fish was done by CCC enrollees, each trip had to be supervised by one of the fish management personnel or a Federal Game Warden.

In certain of the streams that are to be intensively studied all fish that were planted were marked by clipping the fins, and as they were uniform in size when planted, the growth rate can be accurately gauged by periodical examinations of occasional fish and later on when retaken by anglers.

In having four watersheds under control it is planned to have two opened for short periods each season and two kept closed. By this method of alternating the fishing, each stream that has been stocked will be undisturbed for about 21 months before fishing is again allowed. It has been the custom to open the fishing in the Preserve for periods of about a week each in May, June, and July. It may be possible under our present program to increase the number of fishing days each month and also include the month of August when the tourist travel is at its height.

In regulating the fishing on the streams of this Preserve, it is required that each angler in addition to having a State or County license, must procure a special permit for which a charge of $1.00 per day is made. These permits are obtainable from the Forest Supervisor's or District Forest Ranger's office, or when entering the Preserve at one of the checking stations. While the fishing is in progress, temporary checking stations are established at each highway entrance to the fishing areas, where the anglers are checked in against their permits, and again when

returning to record their catch. Fishing is permitted only with unbaited artificial flies. Fifteen fish is the legal daily limit, and the minimum length limit is 6 inches for brook trout and 8 inches for rainbow trout. No person is permitted to fish more than 10 days in one season.

During the short open season in 1937, to better acquaint the fishing public with what is being attempted, a small mimeographed folder was given to each angler as he entered the Preserve. The information given in this folder is shown below:

The outside page of the folder was worded "YOU CAN HELP US, MR. ANGLER." The text on the inside and back pages was as follows: "These streams upon which you are now fishing, have been set aside as a part of a Fish Management Project, which is administered cooperatively by the U. S. Forest Service and the Bureau of Fisheries. A careful biological survey has been made of each stream, and the existing conditions studied to determine just what might be done to develop and maintain better fishing. Regular examinations are continuing to be made of the fish foods, chemical, and other conditions, in order that a permanent stocking policy may be adopted. This must be based upon the numbers, kinds, and sizes of fishes that these streams will support in good condition. Certain of the streams in the various watersheds will be planted with what is thought to be a suitable number and size of the varieties best adapted to the conditions. These fish will be weighed and the average weight recorded at the time of planting. They will also be inconspicuously marked so that if retaken later may be identified as a particular lot. The planting will be done during the late summer and fall and such streams kept closed to all fishing the following season. Under this plan several of the watersheds will be closed and others thrown open each fishing season. Every stream will thus have one season's 'breathing spell' after being fished. In order that a scientific 'check-up' may be made of the results of this program, we are desirous that each angler to whom a fishing permit is issued, will cooperate with us in securing as much information as possible as to the growth, condition, and abundance of fish taken and observed. Therefore, while you are eating your lunch or resting between 'rises', will you not please make notes of just where the fish seemed to be the most plentiful; where the largest were taken, and any other observations that may be of value? And when recording your catch at the 'checking station', please do not assume that because the checkers may seem over-particular in measuring or weighing individual fish, that they are trying to find grounds for some violation of the game laws or rules. They are simply attempting to ascertain just how much this or that particular fish has grown since it was planted and its condition. If we are to have more and better fish for your enjoyment, you can greatly assist us in finding out and reporting such facts as may be observed under actual fishing conditions. U. S. Forest Service Bureau of Fisheries."

At the checking stations upon a special form was recorded the individual results of each angler's efforts as he returned from fishing. These gave the date, permit number, streams fished, time of fishing, section of stream fished, section

where most fish were taken, number undersized fish taken, approximate hours of fishing, as well as the species, number, weight, conditions, etc., of the catch. The weight and length of the largest fish taken by each angler were alsc recorded.

No difficulty was experienced by the checkers in obtaining this information from the anglers, even from those who were disgusted from having caught no legal fish.

During 9 days of open season on the East and West Forks of the Pigeon River, the very complete records show that 750 anglers reported a total of 5,167 fish of which 5,121 were brook trout and 46 rainbows. One hundred and twenty four anglers caught their limit of 15 fish while 143 caught no legal fish, aithough reporting many undersized ones hooked. The average catch per fisherman was 6.88 and the largest fish taken, a brook trout of 16 inches, weighing 24 ounces. Ten thousand brook trout averaging 7 inches were planted back into these waters to replace those taken out. Fishing of this kind cannot be maintained except at a loss when only $1.00 per day is charged for the permit. Either the permit fee must be increased or the number of fish per angler reduced.

Some interesting and enlightening information should be the outcome of these studies and experiments carried on in the Pisgah National Game Preserve, and the results of each particular phase of the program will be reported from time to time in issues of this publication.

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## THE CALIFORNIA TROUT INVESTICATIONS 1/

By Dr. Tracy I. Storer,
Professor of Zoology, University of California,
Davis, California.
Member, Advisory Committee
to U. S. Bureau of Fisheries

SOME YEARS AGO in southern France, I stopped for mid-day dinner at a roadside restaurant. Nearby was the Pont-du-Gard, an aqueduct of Roman construction, and in a cave at the south end of the aqueduct archeologists were uncovering relics of prehistoric men. The region, then, had been inhabited by mankind for centuries. Yet at the restaurant our repast included fresh trout and the total cost of the meal was 22 francs, nominally about 88 cents per person. Inquiry developed that these trout had been caught by local residents in a nearby stream and sold to the restaurant. Later that year in England, on a main motor road within 25 miles of London we crossed

1/ Presented at the Annual State-wide Conservation Meeting, California State Chamber of Commerce, Los Angeles, California, October 28, 1937

a small stream that on inquiry proved to contain rainbow trout. Lord X who held title to the fishing often had the then Chancellor of the Exchequer as his guest and the local water bailiff said "If Neville Chamberlain collects taxes like he takes trout from this water, may the Lord help the British people." The fishing there was evidently highly satisfactory. Still later we coursed along pleasant streams in the Scottish highlands, with an occasional trout fisherman in waters. The streams were unfenced and guardians were few, but signs at intervals bore the legend "Fishing strictly private." In London a young business man gave me a copy of the English annual "Where to fish", in the back of which he had dutifully recorded the catching on hook and line of the skates--almost the only kind of fishing available to him. Upon inquiring into details of British fishing I learned of the system by which few waters save the ocean border and bays are available to the average man, how the rights to fish along inland streams are owned, leased, or rented, and how men of moderate means might organize a club, lease some part of a river or brook and enjoy modest fishing for trout at an outlay of $50 or more per year. I heard of one good trout stream on which a mile of fishing rights brought an annual rental of about £400 (roughly $2,000). Fishing in Europe then is, in high degree, a matter of privilege and to be had only at considerable cost.

In the United States, on the other hand, a different viewpoint has obtained. The Pilgrim pioneers sought upon coming to America to shake off the shackles of class distinction; the constitutional rights of equal privilege for all citizens apply in respect to sport fishing here. During the earlier centuries in America, and until recent decades in California, the privilege of free fishing (for at most a nominal license fee) through a long season and with a generous daily creel limit gave rise to no particular difficulty. Trout and trout streams abounded, while fishermen were few. With increasing human population the picture has changed. First the streams near large centers of population were depleted. Thirty years ago it was said that on the night before trout season opened along Papermill Creek in Marin County, California, there was a red glow every ten feet from the cigars and pipes of fishermen awaiting the opening hour. This creek early became a one-day-per-year stream. The story could be repeated, with variations as to detail, in many parts of California. Not until the turn of the century was any concern expressed for the stocks of fish in mountain streams. Difficulty of access and limited numbers of fishermen left plenty of wild stock for replenishment. Development of the automobile and building of good highways into the mountains together with a great increase in the number of fishermen has markedly changed the picture. Despite relatively enormous expenditures for the artificial rearing and planting of trout (as detailed later) the supply does not keep up with demand save in a few remote districts and in the high southern Sierra Nevada where roads have not yet penetrated. The trout situation in California needs critical attention.

A sick person is seldom benefited by the suggestions for treatment by well-meaning but uninformed neighbors; an unprofitable business cannot be salvaged by listening to the comments of casual customers; and, similarly, the management of the

trout population in California is not going to prosper if conducted on a political basis or directed by the resolutions of groups of sportsmen lacking technical knowledge. A really effective program of trout management can be had only if we first get the necessary facts in hand and second apply those facts as they should be applied to field operations in behalf of trout.

Agriculture has reached a high plane of production in the United States, chiefly because of the large body of accurate factual knowledge that has been accumulated in respect to the requirements of crop plants and domestic animals and because of the widespread application of this knowledge to agricultural practices. Much of the detailed information upon which American agriculture depends has been obtained by research and test in the Agriculture Experiment Stations. These cooperative research units, now celebrating 75 years of useful existence, have been financed from the beginning in part by Federal funds and in part from state funds. Their continuance on an adequate basis is considered necessary by American agriculturists in order that study may be made of new problems as these arise and of old problems under new conditions.

There is a general parallel between agricultural production and trout management. Each deals with the production of living things and their proper care. The production of range livestock involves knowledge of proper breeding stock, the nutritional requirements of the animals, the available forage, the density of animal that may be pastured profitably on a given area, and the maintenance of the forage without depletion.

Proper trout management requires first a scientific survey of existing lakes and streams to determine their suitability for the various species of trout; second, a determination of the amount of trout food available in such waters as a basis for proper stocking policy; and, third, information as to the effects resulting from the presence or planting of different species of trout in any one water. Artificial propagation of trout requires that adequate brood stocks be available, and of strains that produce rapid-growing, gamey fish at minimum cost.

While the management of trout in streams and lakes will probably never attain a basis comparable with that of livestock production, it is fair to contrast the state of knowledge in the two fields.

The livestock producer knows or may learn from books and bulletins, from professors of animal husbandry and farm advisors the kinds of animals to use, their proper care and feeding, the density of stocking that may be practiced on different kinds of range and pasture, the relative forage value of many grasses, herbs, and shrubs, and the carrying capacity of ranges. He may ride among his animals, count and observe them, move them here and there as circumstances dictate, and can inspect his pastures as to the kinds and amounts of forage available.

The trout manager is far less fortified as to knowledge. Only a beginning has been made in learning the suitability of the many species of trout to waters of

different kinds. While the nutrition and growth of trout has been studied in the laboratory and hatchery, there is a dearth of knowledge under natural conditions and in respect to differences in seasonal requirements. The kinds and amounts of trout food produced in lakes and streams has been ascertained in only a few places. The actual carrying capacity of waters for trout and the degree to which natural propagation should be supplemented by artificially reared fry, fingerlings or older fish has received consideration in only a few places.

What may be said of the administration of game fisheries work through the years in this country and particularly in California? We must excuse the activities of early fisheries administrators since most of what they did, often with sincere intent, was based on little or no accurate knowledge, only the sketchiest outlines of trout biology were then known and the complexities of life for trout in a stream under a state of nature were scarcely surmised. We must be lenient in criticism of early activities at transplanting trout and other species indiscriminately into waters to which they were not native, and of the importation of non-native species from other states. The assumption, made many years ago in the absence of facts, that artificial spawning and planting of young would serve to maintain a fishery, was then a fair assumption. But we can and must be more critical toward a blind continuance along the same paths. State fisheries administrators supported by sports-fishermen have carried artificial reproduction and planting to enormous proportions. Twenty-six hatcheries and twenty-seven egg stations, representing capital investment of $750,000, are now used for this purpose in California. Production for 1935 reached the colossal figure of 35,700,000 trout planted.

What of these activities? Even though the sportsmen believe the policy as developed through the years a good one, are they really getting a good return? If not, can anything be done to improve the situation?

In May, 1930, the Klamath River Study Committee of the California State Chamber of Commerce rendered a report based on two years of study of the problems resulting from creation of the Klamath River fish and game district by initiative in 1924. A considerable part of the report had to do with the values inherent in the Klamath River as a stream for sport fishing. One of the major proposals in the report was for a sound scientific study of the steelhead and rainbow trout in California.

Since the fish cultural problems relating to the Klamath River and its tributaries are fundamentally the same as those found in many other sections of the State, it was decided that greater practical value would result if the investigations were conducted so as to include in their scope the principal trout fishing areas.

Following the usual difficulties inherent in establishment of a scientific study, a memorandum of agreement was drawn up whereby the United States Bureau of Fisheries, the California Division of Fish and Game, and Stanford University entered, cooperatively, on this study, which, for short, will be termed "The California Trout

Investigation."

1. The program of research was planned to include the following investigations:

   a. The natural geographic distribution of California trout and the conditions under which they live.

   b. The habits of native trout within their various habitats.

   c. Resultant changes in habits if and when introduced elsewhere.

   d. Life history including spawning, growth, and age

   e. Natural food of trout and the possibility of its increase.

   f. Physical stream environment and possibility of control.

   g. Animal environment, including introduced forms.

   h. Artificial fish propagation with a close scrutiny of present practice, method of rearing, holding, and final distribution.

   i. The effect of various methods of fishing and the possible control of fishermen.

2. The cost of the research was to be borne equally by the California Division of Fish and Game and the United States Bureau of Fisheries.

3. The chief of the research, a scientifically trained man of known capacity, was nominated by the United States Bureau of Fisheries, and approved by the California Division of Fish and Game .

4. The chief of the research was to have power of appointment of all assistants.

5. Stanford University agreed to loan the part-time services of one or more of its academic staff, and provide such laboratory space as was available for the research.

6. The California Division of Fish and Game was to take the necessary legal steps to make the program in Item 1 effective.

The program was formulated jointly by officials of the Division and the Bureau in November, 1930, and placed in operation during the fiscal year 1930-31. Dr. Paul R. Needham, Associate Aquatic Biologist of the U. S. Bureau of Fisheries, was placed in charge and has continued in that capacity. Mr. Alan C. Taft started with the study as a representative of the Bureau of Fisheries but later became Assistant

Chief of the Division's Bureau of Fish Conservation and recently has become Chief of this unit in the State organization.

The staff has included two representatives each from the Bureau and Division with seasonal help as needed. The actual expenditures to date have totalled approximately $100,000.00, each agency contributing about equal amounts.

In addition to these expenditures, considerable sums of money have been expended by the U. S. Forest Service in connection with stream improvement work found desirable as a result of the studies of the Investigation, and an unrecorded amount of CCC labor has entered into this phase of the work. Further, in 1934, $20,00.00 was allotted by PWA for stream and lake surveys and for studies on stream improvement. Results of the work to date have appeared in 20 or more published articles; in three mimeographed reports on the survey work, and in a variety of verbal communications given in meetings, conventions, and over the radio.

The major lines of inquiry of the Investigation, to date, have been as follows:

A. Coastal stream steelhead studies.

Through the aid of a dam and attached trap constructed in Waddell Creek near Santa Cruz, in the summer of 1933, it has been possible to make a detailed study of the life history and habits of coastal stream steel head trout. The two-way trap collected all upstream migrants, as well as most seaward migrants. As a result of this work many facts pertinent to the conservation of steelhead trout have been learned.

B. Stream surveys.

Three 4-man parties during 4 months in the summer of 1934 conducted studies of (1) the Klamath River drainage system, in the Klamath and Shasta National Forests, (2) the San Joaquin River drainage in the Sierra National Forest, and (3) streams and lakes of the Mono and Inyo National Forests. These, it will be seen, represent three distinct types of trout habitat in California, the northwest coastal region and the western and eastern slopes of the Sierra Nevada. The reports give physical and chemical data on the streams and lakes, the fishes present, the kinds of fish food present, observations on the fishing intensity and recommendations for future planting programs, sites for rearing ponds, and stream improvement measures that seem desirable.

These surveys may be considered to be little more than preliminary reconnaissances; it was not practicable, with the limits of time and personnel indicated, to conduct investigations in an exhaustive manner. By way of comparison New York State has been conducting a biological survey of the waters of that state to the end of having adequate knowledge of its aquatic resources and of the needs for planting. This survey, started in 1926, has cost $40,000.00 to $50,000.00 annually and is yet incomplete; a staff of about 40 investigators is engaged for a three-months summer

field period on one or two drainage basins, following which permanent members of the Survey staff prepare detailed printed reports on the findings. The aquatic freshwater resources of California will be imperfectly known until similar studies are carried on here.

C. Experimental rearing of trout in ponds on natural foods.

A 5-year study at Hot Creek, Inyo County, perhaps the most notable, natural site in California, was concluded June 30, 1937. While artificial feeding produced growth of young at the phenomenal rate of about one inch per month, trout on natural food grew at rates varying from 0.45 to 0.63 inches per month in two different years. Selection of brood stock in the direction of producing more rapid growing, high egg yielding, fish was also studied here. In the spawning season of 1937, 839,000 eggs were taken from select rainbow brood females at this station. Through the work of Embody and other investigators, it has been amply demonstrated that by developing selected breeding stocks of trout, strains can be developed that are much more rapid in growth rate than the average run-of-the-stream fish. In New Jersey, selective breeding of eastern brook trout has so increased egg yields that for production of a given quantity of eggs only one-fourth the numbers of brood fish need now be maintained as compared with earlier conditions. This means, objectively, marked reduction in cost of carrying brood stock from season to season and the residue of former costs can be released for other expenditures in behalf of fishermen. Since the available supply of rainbow trout eggs in California is already short (as compared with presumed planting requirements) the advantage of improved brood stocks in California, if and when developed, is obvious.

Other experimental rearing ponds are established in the Shasta National Forest.

D. Development of a non-migratory strain of rainbow trout.

In May 1937 stocks of Salmo nelsoni were brought from Lower California for this project.

E. Experimental planting of marked trout to determine:
(a) Mortality rates after planting as shown by those actually caught by anglers
(b) Production in terms of pounds of fish produced per acre of water area under varying degrees of angling intensity.

The first is being studied in Convict Creek and Convict Lake, Mono County, and in other streams. The second will be studied in various places as opportunity permits. The cooperation of the California Division of Fish and Game, U. S. Forest Service, CCC camps and private resort owners is being used in gathering some data for the second item.

Two samples of the results already obtained by the Investigation may serve to illustrate the practical importance of such studies.

A check of angler's creels on Squaw Creek, Shasta National Forest, in the summer of 1937, recorded 117 catches totalling 2342 trout. *of these 2336 were rainbow trout and only 6 were Loch Leven Trout. In the preceding 5 years, 1932-1936, the state reports having planted in this creek 10,000 Eastern Brook, 120,000 rainbow, and 140,000 Loch Leven. What of the Eastern Brook Trout and the 139,994 Loch Leven planted in earlier years? Not one was taken by anglers this year! The rainbow is native to Squaw Creek; the other two are not. Henceforth on this stream only marked fish will be planted. Subsequent creel censuses will then show the relative importance of natural reproduction versus artificial repopulation. One cannot generalize, safely, on the basis of such a limited study, but one certainly is justified in demanding that facts be had as a basis for a rational planting program.

Since the food costs alone, in hatcheries, range from 25 to 35 cents per pound of trout reared, the expenditure of many dollars for trout food alone in rearing the Loch Leven trout planted in this stream was almost entirely lost.

Angora Lake at 7800 feet and about 7 miles south of Lake Tahoe has been chosen by the Investigation for study of the relations between planting and anglers' catches in a mountain lake. The proprietor of a resort strategically situated on the lake has cooperated in obtaining an estimated 98% census of all catches for 3 years.

On September 26, 1933, 5028 Eastern Brook trout averaging 1.97 inches in length were marked and planted and in 1935, 154 or 3.06% of these were caught. On June 26, 1935, 2080 additional Brook Trout averaging 5.33 inches in length (but differently marked) were planted and 473 or 22.7% of these were taken in the same season. The 154 Eastern Brook trout of the 1933 plant formed 19% of the total 809 trout caught by anglers in Angora Lake in the 1935 season while the 473 from the 1935 plant formed 58% of the total catch of the same year. Marked fish thus contributed 77% of all trout taken in 1935. From these data it is evident that the planting of the larger fish in 1935 (average length 5.33 inches) gave better and more immediate results both in terms of survival and in terms of fish taken by anglers. It should be noted that no marked trout were caught in the 1934 season.

Loch Leven and rainbow trout formed 47% and Eastern Brook, 53%, of the catches in 1934. In 1935 Loch Leven and rainbow made up only -.7% of the number taken while Eastern Brook formed over 99% of the catches. It is evident from these data that consistent heavy stocking with one species can quickly modify the catches in a small lake like Angora in a single season.

This Investigation is the first serious major effort to develop a body of accurate information regarding trout in California. Since the establishment of the first state hatchery in 1883 and down through the years until very recently the

*Data only to Sept. 9, 1937

administration of inland trout fisheries had no professionally trained personnel. When Dr. J. O. Snyder became Chief of the Bureau of Fish Culture in 1932, that Bureau came, for the first time, under direction of a technically trained biologist. The entire direction and supervision of the State's program earlier had been under self-educated men, lacking, in the main, a critical scientific approach to the subject of trout management. The utter lack, in earlier years, of articles of scientific character dealing with California trout (save for occasional papers by Jordan, Evermann, Snyder and a few others, chiefly on the classification of trout) is but an indication of the short-comings of the program, prior to establishment of the present Investigation.

The rearing and planting of trout has been practiced in California for many years. Some early efforts in rearing were conducted by private enterprise and the State bought young for planting as early as 1877. The first state hatchery was established near Mount Shasta in 1883. In the 1890's and even early in the present century small appropriations for fish culture were made biennially by the State Legislature. Thus in 1893 and 1894 the sum of $12,500.00 was spent on hatcheries and 5.4 million trout were planted. In 1935, the most recent year for which figures are available 35.7 million trout were planted, the total cost as represented by expenditures of the Bureau of Fish Conservation being $313,000.00. Thus, according to official reports, gross production has increased 7-fold and gross costs 25-fold, hence the cost per fish in 1935 was four times that in 1893. Some increase in cost might well be expected considering dollar values then and now in respect to materials and labor, and also because of greater refinements in the processes of rearing and planting.

In addition to the expenditures by the Division in behalf of game fish, there are the expenditures and services of fishermen and local clubs in the work of fish planting. These, if known, would but serve to increase the amount actually chargeable to the rearing and planting of game fish and would decrease the already small percentage fraction of the cost of the investigation as compared with the total expenditures in behalf of game fish in California.

It should be emphasized that these expenditures are preponderantly in behalf of trout, the most important game fish in California.

The cost of the Investigation as compared with the income and expenditures in relation to work on freshwater fishes by the Division of Fish and Game is infinitesimal as shown by the following tabulation (based on figures from biennial reports of the Division for the period included):

| Year | Receipts from angling licenses | Expense Bureau of Conservation | *One-Third Cost of Patrol | Total Expense for Game Fish | Cost of Investigation | Investigation cost in percent of Total |
|---|---|---|---|---|---|---|
| 1932 | $436,000 | $293,000 | $141,000 | $434,000 | $3,161.00 | 0.73 |
| 1933 | 358,000 | 256,000 | 116,000 | 372,000 | 6,616.00 | 1.77 |
| 1934 | 430,000 | 287,000 | 126,000 | 413,000 | 5,533.00 | 1.35 |
| 1935 | 457,000 | 313,000 | 133,000 | 446,000 | 4,333.00 | 0.97 |
| Average | $420,000 | $287,000 | $129,000 | $416,000 | $4,914.00 | 1.18 |

*One-third of total cost of Bureau of Patrol is assumed to be spent in behalf of trout.

What may be expected to result from continued study by such a research organization as the California Trout Investigation?

First, material additions will be made to knowledge of the biology of trout in California. The requirements of each of the several species of trout will be determined in respect to food and shelter and their suitability for planting in waters of different character.

Second, the planting of marked fish, ranging in size and age from fry to young adults, in different numbers in waters of various lakes and streams, upon subsequent recapture of these by fishing or by experimental seining, will show survival rates and point the way to more effective stocking policies. If, for example, marked rainbow trout are planted in a stream already containing this species, information will be obtained on the relative importance of natural reproduction as compared with artificial repopulation by hatchery reared stock. Such studies will also indicate what intensity of planting is necessary to maintain stocks for satisfactory fishing.

Third, development of selected lines of brood stock will tend to reduce the costs of egg production. The trout farmer (in California the State Division of Fish and Game, "hired" by the anglers' license fees to perform this service for the fishing public) should have productive brood stock that does not figuratively "eat its head off" in the pond between spawning seasons.

Fourth, more and thoroughly adequate stream surveys can be made, if funds permit. These are as essential for a proper program of trout management and perpetuation as is the timber cruise to a forester or the grazing reconnaissance to a stock grower.

It is appropriate that the United States Bureau of Fisheries invest time and effort in the conduct of such studies in California. Over one-third of this state is Federal property, and a fifth is of nationally owned forests in which are many of

the most desirable trout waters in the state. Participation by the Bureau of Fisheries facilitates cooperative effort with the U. S. Forest Service as is already occurring. But cooperation by and with the State Division of Fish and Game is also very important. The genesis of this Investigation as a cooperative effort linking the national and state agencies was highly appropriate inasmuch as the production of artificially reared fish for planting as a means of supplementing the wild supply is done wholly by the State Agency in California. Had there been an effective and functioning study under way by the state, there would have been less need for Federal activity save as the Bureau of Fisheries can bring much of critical judgment as to work in other states. The object is, however, now a cooperative one and in the interest of doing work that is sorely needed as a basis for application in fish conservation. It should continue.

California may well consider material supplement to the investigational program now under way. The relatively minute fraction of income from angling licenses now devoted to research should be doubled or trebled. The stock of available rainbow trout eggs is deemed insufficient by competent authority and the stock of catchable fish is considered too small by many trout fishermen. Only sound research, adequately financed, can point the way to solution of this dilemma. Only when a substantial body of accurate knowledge is at hand concerning the business of trout management in California can there be expectation of material improvement. The rise in cost of production of hatchery trout, through the years, leaves little hope of greater production on the existing basis. The carrying capacity of lakes and streams in terms of trout per acre or mile of water is the only basis for economical use of the production facilities now available; otherwise there is wastage of feeding little fish to big fish. Only by a really scientific approach to the subject of trout management in California is there expectation of surmounting current complications and maintaining the American system of fishing for all who will buy a license. Many enjoy the pastime of fishing, but few are content with fishing alone; some tangible return in fish is considered desirable else the game loses its zest!

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# GLIMPSES AT FISHERIES BIOLOGY AND FISH CULTURE IN EUROPE

## IV. ENGLAND AND SCOTLAND

By William E. Ricker, Pacific Biological Station,
Nanaimo, B. C.

THE BIOLOGICAL and fisheries research stations of England are principally on the sea-coast, (Plymouth, Lowestoft etc.) and concerned with marine fauna and ocean investigations generally. In the past ten years however permanent laboratories for the study of fresh water life have been established, of which two will be mentioned.

The Avon Biological Research of the University College of Southampton comprises a series of investigations and experiments on the river of that name in Hampshire, centering about its important salmon run. The program has been from its inception under the care of Research Officer John Berry, versatile naturalist of the Kingdom of Five. The life history of salmon in the river, their migration up and down stream, ladders over partial obstructions, screens to protect side channels, the marking of smolts to ascertain percentage return from the sea, have all received the attention of himself and his associates. Several small-scale experiments to test the efficiency of natural spawning of salmon in the river have been made, and also determinations of the success of artificial propagation by eyed-egg planting and fry liberation. Circumstances do not yet permit a fully controlled experiment to ascertain the efficiency of smelt production in the river as a whole, but that is an objective for the future. Other fish of the river, particularly trout and graylings, have not been ignored. The claim of Mr. C. Stratton Garrish, that the slow growing wild stock of trout in the Avon is much superior to an introduced fast growing stock, started a controversy in Britain which has been echoed from the pages of the Progressive Fish Culturist. Mr. C. R. Stonor has made experiments on the effect of iodine on growth of trout.

On the west side of Windermere, largest of the English lakes, is situated the laboratory of the Fresh water Biological Association of the British Empire. It is located in Wray Castle, a monument of the last century whose walls strive to create an impression of age and venerability, but deceive with difficulty even a transatlantic visitor. The interior has been admirably fitted with laboratories and living quarters, and provides a very suitable, if unusual, station for limnological research. Our visit happened to coincide with that of the members of the Council of the FRA, among whom may be mentioned Prof. F. E. Fritch, algalogist of Queen Mary College, London, and the secretary, Mr. J. T. Saunders of Cambridge University. The then Naturalist-in-Charge of the Laboratory, Mr. R.S.A. Beauchamp, is visiting various biological and fisheries stations of America this year. Among the investiations carried on under his direction was a program of tagging the trout of the lake, from subsequent recoveries of which the approximate population was calculated after

the most desirable trout waters in the state. Participation by the Bureau of Fisheries facilitates cooperative effort with the U. S. Forest Service as is already occurring. But cooperation by and with the State Division of Fish and Game is also very important. The genesis of this Investigation as a cooperative effort linking the national and state agencies was highly appropriate inasmuch as the production of artificially reared fish for planting as a means of supplementing the wild supply is done wholly by the State Agency in California. Had there been an effective and functioning study under way by the state, there would have been less need for Federal activity save as the Bureau of Fisheries can bring much of critical judgment as to work in other states. The object is, however, now a cooperative one and in the interest of doing work that is sorely needed as a basis for application in fish conservation. It should continue.

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A list of the institutions mentioned in the text above is appended, with addresses. In many cases directors or librarians expressed a desire to initiate exchanges with American fisheries or limnological publications.

Fresh-water Fisheries Research Institute, Natural History Museum, Oslo, Norway. Director: Prof. Dr. Knut Dahl.

Statens Forsoksanstalt for Sotvattersfiske, Drottringholm, Sweden. Director: Dr. Gunnar Alm.

Limnological Institute, Lund, Sweden. Acting Director (1935): Prof. Dr. Torstem Gislen.

Fresh-water Biological Laboratory, University of Copenhagen, Hillerd, Denmark. Director: Prof. Dr. C. Wesenberg-Lund.

Marinbiological Laboratory, Charlottenlund Slot, Denmark. Director: Dr. A. Vedel Taning.

Danish Biological Station, Charlottenlund Slot, Denmark. Director: Dr. Blegvad.

Fresh-water Fishery Station, Frederiksdal bei Lyngby, Denmark. Director: Dr. C. Otterstrom.

Hydrobiologische Anstalt der Kaiser-Wilhelm-Gesellschaft, Plon (Holstein), Germany. Director: Prof. Dr. A. Thienemann.

Preussische Landesanstalt fur Fischerei, Muggelseedamm, Berlin-Friedrichshagen, Germany. Director: Prof. Dr. H. H. Wundsch.

Laboratoire d'Ichthyobiologie et de Pisciculture d l'Universite de Cracovie, Rue Wybickiego 1, Cracow, Poland. Director: Prof. Dr. Theodor Spitschakoff.

Kossino Limnological Station, Moscow G, Postbox 177, U. S. S. R. Director: Dr. L. L. Rossolimo.

Statni vyzkumny ustav rybarsky a hydrobiologicky, Trida Krale Jiriho 839, Prague XIII, Czechoslovakia. Director: Dr. Rudolph Pytlik.

Department of Hydrobiology and Ichthyology, Zoological Institute, Charles University, Prague, Czechoslovakia. Director: Prof. Dr. Karel Schaferna.

Hydrobiologische Donaustation, Kaisermuhlen, Vienna II, Austria. Director: Dr. A. Cerny.

Biologische Station, Lunz am See, Niederosterreich, Austria.
Director: Prof. Dr. Fr. Ruttner.

Laboratoire de Limnologie, Ecole National des Eaux et des Forets, Nancy, France. Director: M. le Prof. E. Hubault.

Centre National d'Hydrobiologie Appliquee du Paraclet, 10 Rue du Mons Prolongee Amiens (Somme), France. Director M. Paul Vivier.

Avon Research Project, University College, Southampton, England.
Director: Mr. John Berry.

Fresh-water Biological Association of the British Empire.
The Laboratory, Wray Castle, Windermere, England. Naturalist-in-Charge. Mr. E. B. Worthington.

Fishery Board for Scotland, 101 George St., Edinburgh, Scotland.
Director: Mr. W. J. M. Menzies.

Fishery Board for Scotland, Marine Laboratory, Aberdeen, Scotland.
Director: Dr. R. S. Clark.

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# AERATION OF WATERS FOR TROUT

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By Edward R. Hewitt, New York City

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WHILE THE AERATION of trout waters has been studied for a considerable time, it has not generally received the attention it deserves. I have been investigating this subject during the last few years and the results of this study may I hope prove of interest to others.

Although no definite line can be drawn at just what content of oxygen in water trout do well, or just where the deficiency begins to injure the health of the fish, we have a fairly good idea at present about what these figures probably are. Of course much depends on the water temperature and the chemical composition of the water itself. Plehn in Practicum der Fischkrankheiten states the trout do well in water where oxygen is 7.15 parts per million if the water is not too warm. With 4.29 parts they do not do well. With 2.82 parts they suffer and become sick. With 2.14 parts they die at once.

Schlaperclaus in Lehrbuch der Teichwirtshaft, states that 5.5 parts is already critical for trout. With 4 parts faster breathing begins. With 3 parts they cannot

stay long without trouble, and with 1.5 to 2 parts they die at once.

These figures agree with my own personal experience and I have come to the conclusion that 6 parts of oxygen is the lower limit at which trout do even fairly well in soft water. I have no hatchery experience with waters of a higher pH than 7.0 to 7.2. It has always seemed to me that trout in water of about 6.0 parts oxygen were much more subject to diseases and grew more slowly than when the water contained 8.0 or more parts of oxygen. Fry are more sensitive to low oxygen than larger fish as they consume about 2-1/2 times as much oxygen for their weight as do fish of a half a pound or more. They have a much more rapid metabolism.

These facts point to the very great desirability of maintaining the oxygen in trout waters above 7.5 parts at all times and over 8 parts if possible. This is especially so when we remember that feeding may make a very sudden lowering of the oxygen due to the oxidation of the organic matter. Fry have often been greatly injured at feeding time in troughs by this sudden lowering of the oxygen content and in some cases great mortality has resulted where the oxygen previous to feeding was already low.

Where hatchery pools are in series using the same water from pool to pool, I have on several occasions made tests and generally found that the oxygen was brought down to about 6 parts in the first few pools and then remained at near this figure for the remaining pools. As no explanation of this pnenomonen was available, I started to investigate.

Oxygen is absorbed by still water surface very slowly. Laboratory tests showed that at 59 deg. F. the absorption was .98 part for one gallon per square foot per hour or .016 part per minute. With air blown over the surface at four miles an hour the absorption was 2.7 times as rapid or .043 parts per square foot per gallon per minute. (May this be a reason why trout rise better on a lake when there is a slight breeze blowing?)

Numerous tests at my hatchery have shown that trout in a clean sterilized tank in which they have been fed, consume varying amounts of oxygen per pound of fish. These tests were made in a round tank 45" diameter 14" deep using one gallon flow per minute. Water temperature 46 deg. F. Oxygen in water: 10.5 parts. The fish were allowed to stay in the tank over night after they had been weighed so that the water would reach a balance. Most of the tests were on fish of 3" to 4" long but some were made on larger fish. The consumption per pound of fish varied from .08 parts of oxygen for large fish to .36 parts for 3" fish per gallon per minute. The variations were not only due to the activity of the fish but also more to the variable amounts of food particles and excrement present and also to the condition of the walls of the tank, whether it was covered with a coat of fungus or not. We are not interested in the exact oxygen consumption of the fish themselves but on the amount of oxygen they and the tank consume. If we allow .36 parts of oxygen per pound of trout per gallon per minute we will have ample oxygen for health. More figures of this kind should be obtained under other circumstances and they would enable us to figure better on our oxygen supplies.

I calculated that a round 20 foot pool with no flow of water would be able to carry 14 pounds of trout from surface absorption alone and found this to be quite possible. This no doubt partly accounts for the good results with very large pools for trout.

Observations show that oxygen is more readily absorbed under any circumstance when it is low than when near to saturation. The reason for this seems to be that any means of adding oxygen replaces a certain percentage of its deficiency of saturation no matter what this may be. For instance suppose saturation was 10 parts, and the water to be oxygenated 5 parts and the efficiency of the oxygenating device 30% it would put in 30% of 5 which is 1.5 parts. But suppose the water to be charged was 8 parts the device would add 30% of 2 parts or .6 parts only. This shows the very great importance of securing a device which will have a high efficiency if we are to obtain water high in oxygen with a single aeration. Unfortunately many of the devices we now use only have efficiencies of from 5 to 10%. It is easily seen that we cannot hope to maintain a high enough oxygen percentage for the best health in our trout. A fall of water of 150 gallons a minute falling 20 inches over a weir 8" broad only raised the oxygen from 6.0 parts to 6.5 parts. A brook from 30 to 40" wide running 150 gallons a minute very fast over gravel bottom for 200 feet only raised the oxygen from 6.5 to 7.0 parts, and another fall of 20" over a weir 30" wide only brought the oxygen up to 7.4 parts. It will be seen that with two falls of total 40" and a brook of 200 feet only raised the oxygen from 6 to 7.4 parts. I give these as illustrations of ordinary practice. Fortunately an excellent study of the subject has been made by Mr. Paul A. Shaw which was published in "California Fish and Game", the organ of the California Fish Commission. His results enable us to secure a marked improvement over current practice and I would advise anyone interested in securing the best aeration to secure a copy of his paper. It will be found in Vol. 22 No. 2. I will give a short summary of his results.

He secures excellent aeration by the use of only a 10" fall and an efficiency of 30% or better. I have checked his experiments personnally and found that he understated rather than overstated the results.

He uses a saw tooth edge to the fall of water each tooth being 3" wide and 4-1/2" long bent downward so that the water follows the tooth and leaves the end in a stream. This drops into at least 6" of water. From 10 to 24 gallons of water per minute can be run over each foot of width or four teeth, and get good aeration. More flow reduces the aeration and less than 10 gallons does not do so well. I use #18 gauge aluminum for making the saw teeth as this is cheap and permanent. Copper is too expensive and galvanized will always rust in time. This device is entirely practical and will not clog up and requires no attention. It will probably increase the oxygen from two to three times more than is now put in by ordinary means.

In order to comprehend why this device works so well I attempted to get at the physics of it to some extent and my explanation of Mr. Shaw's experiments is as follows:

All water surfaces are under capillary tension which amounts to .075 grams per linear centimeter. This is true of bubbles as well as flat surfaces. It is evident from the very slow absorption from a flat surface that this tension must some what prevent the oxygen from getting in. This is especially so because the solubility of water for oxygen is so very slight. To get a rapid absorption this capillary tension must be broken down and the oxygen brought in contact with the water where it is broken. In order to prove this I made an aspirator and sucked water through it by a blast of air. The recovered water was completely saturated immediately. Again water sprayed forcibly through fine holes becomes saturated. When aerator stones are used it takes about 30" of water pressure to overcome the capillary attraction of the water in the fine pores. The air forced through the stone must overcome this pressure and this brings it in contact with the water at a point where the capillary film is broken. This accounts for the efficiency of this device. Shaw's method carries a film of air down the water stream into the water below and the force of the stream breaks the capillary film and the air carried down is largely absorbed. If the stream is large the amount of air carried down is small for the amount of water and aeration is consequently very low. This explanation seems to fit all the facts

It seems evident that it is a simple matter to raise the oxygen content of our trout pools much more than at present wherever a fall of 10" is available and this will improve the health of our fish. There seems to be no reason why Mr. Shaw's device should not be very largely adopted in trout hatcheries.

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## ABSTRACTS OF SELECTED PAPERS PRESENTED AT THE 67TH ANNUAL MEETING OF THE AMERICAN FISHERIES SOCIETY

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THROUGH the courtesy of the Secretary, Mr. Seth Gordon, The PROGRESSIVE FISH CULTURIST again presents advance summaries or abstracts of a few of the many interesting papers presented at the meeting of the American Fisheries Society held August 23-25, 1937 in Mexico City, U. S. M. Although the published Proceedings will contain a full account of the meeting which was notable because of its strong international aspect, a few of the presentations of most interest to fish culturists are presented in condensed form as an appetizer for the entire volume when it is ready for distribution. Remember that members of the Society receive copies of the Proceedings free.

## FISH CULTURE - PAST AND FUTURE

By A. G. Huntsman, Ph.D.
University of Toronto, Toronto, Canada

Author's Summary

Belief in a general depletion of the virgin stocks of fish, and enthusiasm over the new procedure of hatching fish eggs and planting the fry that arose in the sixties of the last century served as powerful stimuli to the development of fishery services and the intiation of scientific study of the fisheries in both the United States and Canada. The early fish culturists were the persons who started this Society in 1870. The peak of the development of the early simple fish culture was reached about the turn of the century, since which time there has been retrenchment as well as attempts to determine what practice is effective and to develop methods that will ensure the desired results.

Many fish, such as the Atlantic salmon that spends part of its life in the sea, are susceptible merely to partial fish culture. That fish, as studied in the Maritime provinces of Canada and particularly in the Margaree River, is available in the river in the adult stage depending upon variable forces, principally stream flow, which may have to be controlled to assure angling. Control of stream flow seems also neces sary to prevent mortality in speckled trout by bringing them from a shallow lake into cold brooks before the water becomes too warm in summer, and to prevent mortality in spawning gaspereaux by bringing them up from the tidal waters of a shallow estuary which exposes them to great changes in salinity. Control of kingfishers and mergan sers on streams inhabited by young salmon seems definitely indicated as the most important measure for maintaining the stock of salmon at a high level. The tradi- tional fish culture may be made effective by a scientific distribution of the young salmon to suit very local conditions. Possibilities also exist for increasing the salmon stock by stream improvement, which may be effective when the requirements of the young salmon are adequately known and when procedure has been accurately tested.

## HATCHERIES MANAGEMENT IN MEXICO

By Felipe B. Berriozabal, Department of For- estry, Game and Fish, Mexico City, Mexico

Fish culture in Mexico is in a very undeveloped state. The interior waters, particularly in the high plateaus, are poorly populated by good species of fish, and additional supplies are required to supplement the poor diet of the peasant class and

to provide for sport fishing. Little or nothing had been done by previous administrations regarding practical fish culture. A few private hatcheries were started for the commercial sale of fish to nearby cities as luxuries to the well-to-do classes.

Observing the success of a trout hatchery located at one of the springs feeding the Lerma River, a plan to establish other hatcheries for stocking this river throughout its course was developed. The first station was established on the Almoloya River for the propagation of rainbow trout. Last year a small laboratory was established at the same place and plans were made for bringing a sufficient number of eggs from the United States during October to completely stock the hatchery. At the present time, August, we have as an experiment some 60,000 trout that have reached a size of six inches. A second smaller hatchery will be built in the near future for the propagation of brook trout. The department has also begun the distribution in suitable waters of black bass which were brought from Lake Patzcuaro, Michoacan, where the species has become abundant.

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## STUDIES OF THE EFFECT OF COAL WASHINGS ON TROUT

By Clarence F. Pautzke, Department of Game, Seattle, Wash.

Experiments were undertaken to test the effect on steelhead and cut-throat trout of waters flowing from extensive coal washing operations into the streams of the Cascade Range in Washington. Coal mined in this region is semi-bituminous, low in sulphur content and high in waste materials of slate and sand particles. Mechanical washers using 250 gallons of water per minute in one plant discharged approximately 22½ tons of solids per day into the streams for each mechanical unit operating.

Ten young steelheads averaging six inches in length were placed in a wire screen cylinder in the polluted area of the stream. A similar number were used as controls in the unpolluted area. All of the fish in the polluted water died within 2½ hours; none of the controls died in the upstream water when left overnight. Examination of the dead fish disclosed a heavy secretion of mucus covering the bodies and around the gills were solid masses of coal dust and slate particles. The gills were faded in color, and quantities of coal dust were found in the stomachs of the fish. The internal organs were congested with blood.

Similar tests with young cut-throat trout one to two inches long showed a higher toxic effect of the coal washings. The fish died in 30 minutes; the controls held overnight in water pumped from the mine showed no mortality.

One of the coal companies constructed settling basins large enough to accommodate the total water output during one working period of 12 hours. The accumulated coal

dust in these basins was sold as cheap grade stoker coal at $1.25 per ton which paid for salvaging.

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## FACTORS INFLUENCING FISH FOOD AND FISH PRODUCTION IN SOUTHWESTERN STREAMS

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By Clarence M. Tarzwell
U. S. Forest Service, Albuquerque, N. M.

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### Author's Summary

For the past two years surveys have been in progress on the mountain streams of the southwest. These surveys include chemical analyses, quantitative counts of bottom food organisms, a study of the physical character of the streams, and studies of the fish such as species present, relative abundance, age and growth rate. An intensive creel census has been undertaken in several streams.

In addition to the regular surveys, an intensive study is being made on two experimental streams, one of which has been improved to the practical limit and the other left in its original condition.

The surveys have shown that vegetative cover on the water shed and especially in the canyon bottoms is of great importance in maintaining productivity. Vegetative cover is essential for retaining moisture and preventing severe floods which have been found to be the outstanding limiting factor in southwestern streams. Floods not only roll and grind the bottom materials and widen the stream bed destroying pools and cover, but they also sweep away rich organic materials essential for an abundant bottom fauna and deposit light colored inorganic silt which is almost barren of life. It has been found that streams not subject to severe floods for some years are much richer than those streams having frequent floods.

Studies made on the experimental streams clearly demonstrate this fact. These two streams--Upper Tonto Creek and Horton Creek are similar in character and water supply. The unimproved stream, Tonto Creek, is, however, two tenths of a mile longer and has a larger flow. Formerly it was considered the best fishing stream.

Since improvement, however, an intensive creel census and food studies have shown that the improved stream, Horton Creek, is now the best stream. Last year it was found from food studies made at different times throughout the year that Horton Creek had an estimated yield of over 300 pounds more food than Tonto Creek. Also the creel census revealed that Horton Creek yielded a greater number of fish. In addition the catch per hour was greater on Horton Creek and the average total for each fisherman was greater. Scale studies reveal that prior to improvement the growth rate of the fish was more rapid in Tonto Creek, but since improvement it is more rapid in Horton Creek.

On the average these two streams yielded over sixty pounds of trout to the acre of of stream. At the market price for trout this is a return of $36.00 an acre for meat alone, not taking into consideration the recreational value. This is a very good return for any southwestern land and gives a more definite idea of the real value of the fish resources of the southwest.

## NATURAL REARING ENCLOSURES FOR BLACK BASS

By D. S. Rawson
Dept. of Biology, University of Saskatchewan

Author's Summary

A new procedure for both the introduction and rearing of small-mouthed black bass has been tried in lakes of the Prince Albert National Park. The adult bass were transferred before the spawning season and confined in enclosures screened off in protected parts of the lake. This procedure allows protection of the parent stock, prevents undesirable scattering and makes possible accurate observation of survival, spawning activities, etc. In this case 85 adults in enclosures produced 85,000 fry while intensive search revealed no nests from 215 bass released in the open lake.

Rearing was accomplished in "natural" enclosures i.e. protected areas suitable for spawning and cut off by fences of 1 inch mesh galvanized wire. Within these enclosures the bass were handled according to the usual practice in "artificial" rearing ponds.

The chief advantages of the methods used lie in the degree of control over the introduction of the adults, the economy of rearing and the ease of distribution of the fry. It is suggested that similar enclosures might be used in rearing stations either temporary or permanent for bass and related species.

## MIGRATION AND DEPLETION OF STOCKED BROOK TROUT

By Earl Hoover, State Biologist, Fish and Game Department, Concord, N. H.
and
M. S. Johnson, National Park Service

During the 1936 fishing season projects were established to ascertain the migration of stocked brook trout, the recovery of stocked trout by anglers, and the depletion of the stocked fish in several New Hampshire streams. Several experimental stockings of brook trout were made in Bear Brook, a typical, heavily fished trout

stream in southern New Hampshire. Two thousand trout stocked in June during the open season produced better fishing than 4000 trout stocked in the fall and early spring. Five hundred trout were tagged. At the end of the first week 45 percent were taken; att the end of the second week 60 percent; and at the end of the third week 70 percent.

Most of the trout tagged were caught downstream from the point of stocking, but the last few were taken upstream. Trout planted at intervals along the brook were not caught as quickly as when a large number were liberated at one place.

In the two experimental streams maintenance of good fishing depends upon repeated stocking. There is nothing in the data to indicate that the catch of trout in Bear Brook in 1936 was increased by the stocking in the fall of 1935.

## COMMENTS FROM OUR READERS

### PLAN FOR HATCHERY MEAT ROOM

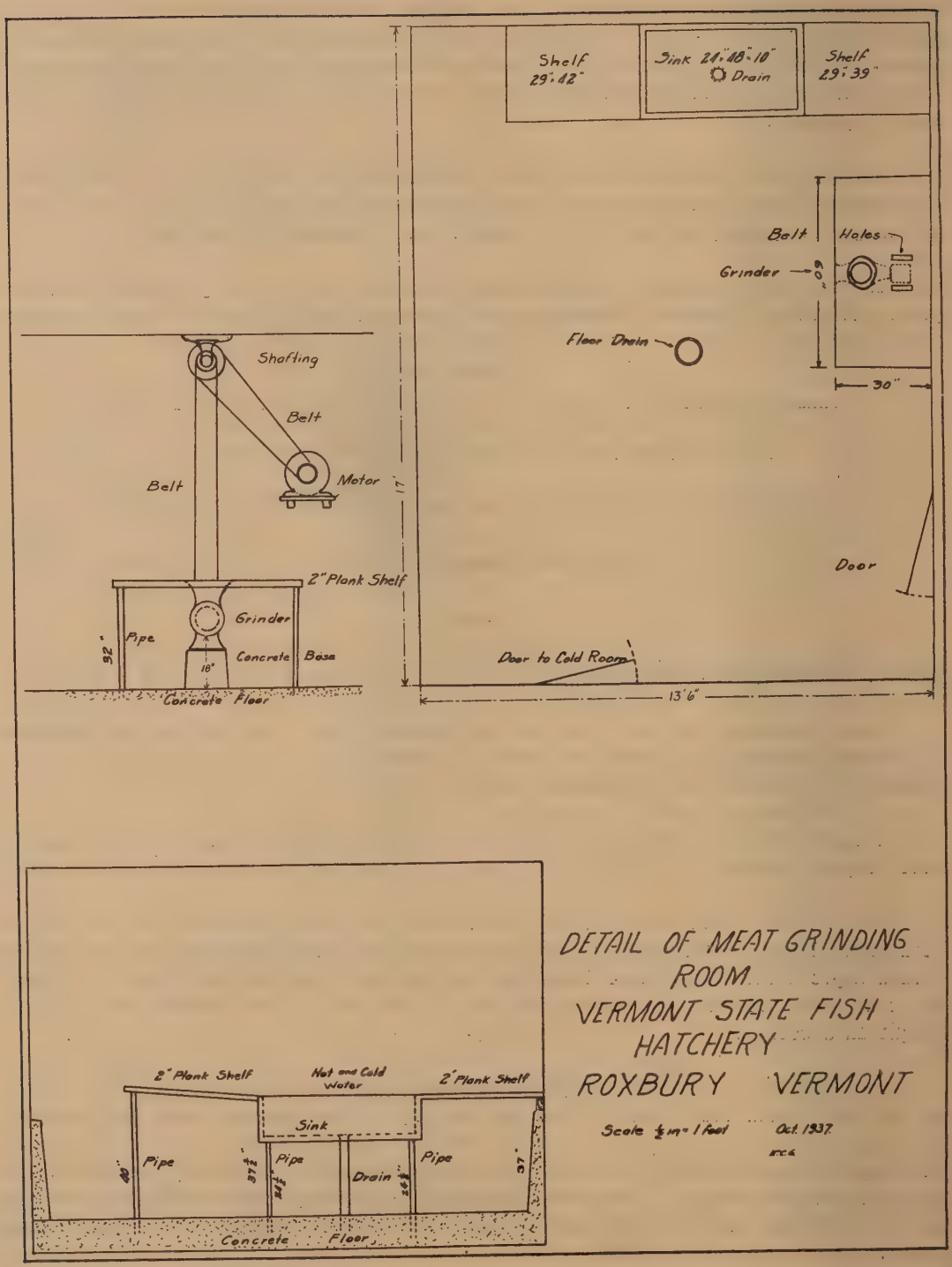
Editor, PROGRESSIVE FISH CULTURIST:

In re-designing the meat room for the Vermont State Fish Hatchery at Roxbury, a plan was sought which would increase the efficiency of the grinding operation. Details are shown in the accompanying sketch.

A smooth finish concrete floor is installed, sloped to a center drain with a bell-trap and screen.

Hot and cold water is piped to the sink constructed of 2 inch maple stock lined with sheet lead. Two shelves sloped to drain to the sink which are constructed of 2-inch maple stock. The water lines are provided with hose outlets under the sink. The sink drain has an elbow above the trap so that blood from thawing meat may be caught in a bucket.

The grinder selected is the Enterprise No. 51 mounted on a 12-inch base doweled to the floor with iron rods. A table, 32" high is constructed over the grinder. The lip of the grinder hopper is 1/4" below the table top, which is cut to receive the hopper. A sloping copper lip is securely tacked to the table-top completing the union of table and hopper. Two holes behind the grinder opening allow passage of the belt. The 5 h.p. motor is mounted on heavy wall brackets and belted to the ceiling shaft.




# DETAIL OF MEAT GRINDING ROOM VERMONT STATE FISH HATCHERY ROXBURY VERMONT

Scale ½ in = 1 foot Oct. 1937

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Meat is thawed in the sink, trimmed on the sink drain-board, passed to the grinding table where it is readily fed into the hopper. The discharge lip of the grinder is 18-inches above the floor which allows room to grind into tubs or large cans. Ground food is transferred to the cold room for storage.

The height of the door thre-holds is about 1/4" to allow easy passage of hand trucks. The thresholds were moulded, and reinforced with heavy strap-iron when the floor was poured.

During the feeding period, about 1500 pounds of meat are ground each week. Three grinding days is the usual schedule. Each requires about one-man-day.

R. P. Hunter,
Fish & Game Service,
Montpelier, Vt.

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## "THE DAYS OF FISHING FOR FISH ARE OVER."

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Editor, PROGRESSIVE FISH CULTURIST:

It has been quite some time since I've written you, and I wish to thank you for continuing my name on your mailing list.

Your publication is still as interesting as ever, and will be more so, I think, judging from the policy you have adopted. I trust you will keep up the good work.

I was in Pennsylvania for 7 months this last year (1937) and had some good fishing. They have good waters there and my one objection to their policy is that I think more money should be spent on brown trout propagating and planting and less on brook trout. Most of the brooks are planted to be caught out immediately and I do not find sport in catching 7 inch trout. However, I like the way they do things there, especially their separate licenses. Some day the commission of the state will get courage to adopt a like policy. It is ridiculous to think of any State providing adequate fishing and hunting for $2.25 in annual fees. It takes years, however, for ideas to sink in.

I think the important thing facing conservation bodies today is the problem of getting across to the sportsmen of the various states the knowledge that the days of fishing for fish are over; that in its stead we must substitute the practice of fishing for sport only. Game limits are still too high; and should be immediately restricted. There is no real problem of conservation which can not be solved if sportsmen cooperate, but without their assistance, fishing is bound to get poorer each year.

I think (still) if more fishermen received your publication and became acquainted with the problems and worries of raising fish, more enlightenment would result than is now found. I also think if you could induce some conservationists and different angling authorities to write a few articles along these lines for your publication, the reaction certainly would be of great benefit to the cause of better fishing.

With best wishes for the New Year, I am

Sincerely yours,

T. W. Timmens,
Batavia, New York.

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## BABY TROUT FEEDING GADGET

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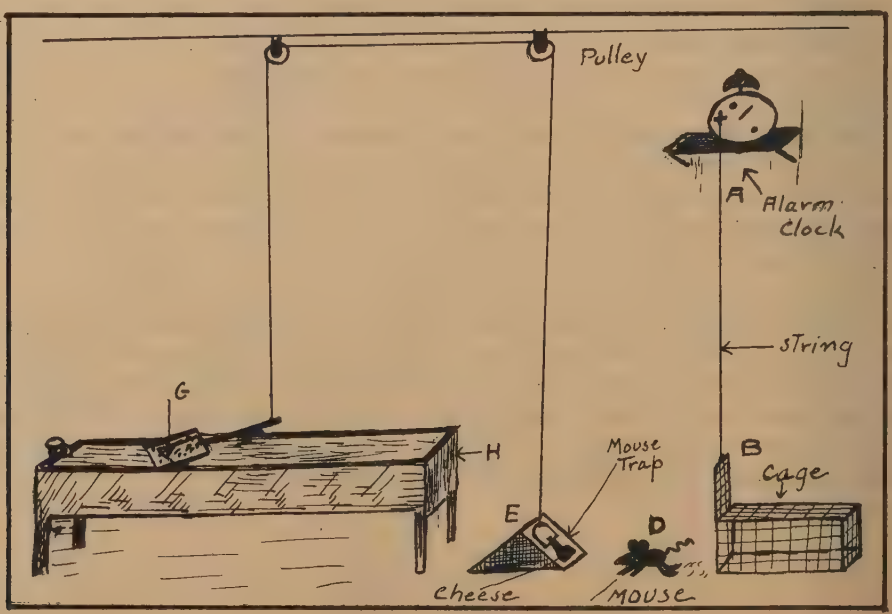
Editor, PROGRESSIVE FISH CULTURIST:

We read in your recent editorial that you are anxious to have illustrations of modern devices used in fish culture .. .. .. .. ..

You no doubt have felt like sleeping late some morning or like taking a nap in the afternoon only to find that you had to feed those baby trout instead. We were slaves to the fish at our private hatchery until we invested the device shown in the accompanying diagram. Now we have time to follow other cultural pursuits.



Our device operates as follows: When the alarm (A) rings, the spool on the back of the clock winds up the string which opens the sliding door to the mouse cage (B). The mouse (D) is awakened by the alarm. It is hungry (C) and leaves the cage. It smells the cheese and tastes it. When the trap (E) snaps it pulls a string which pulls the handle of the feeder (shaped like a pancake turner), which jerks up and drops the food (G) into the trough (H).

The device is very easy to make and costs very little. It can be used for any number of troughs. For example, if a dozen troughs are in use, a dozen mice can be placed in the cage.

We call this device the Restful Slumber Baby Trout Feeder.

Some of your readers might want to try it.

Yours truly,

Inventor.

P.S. We would surely like to come to Washington some day and see your hatchery. It must be quite a hatchery--you putting out your own magazine and all---

## REVIEWS

"Natural Reporoduction of Quinnat Salmon, Brown and Rainbow Trout in certain New Zealand Waters", by Derisley F. Hobbs. New Zealand.--Marine Department, Fisheries Bulletin No. 6, 104 pp., Wellington, 1937.

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BECAUSE OF the important place that artificial propagation holds in conservation programs, all scientific data that permit a comparison of the relative efficiency of artificial and natural propagation must be accorded an eager welcome. Since the primary purpose of hatcheries is to protect the fish during the vulnerable stages of its life history there can be no assurance of the value of artificial propagation until actual comparisons with natural reproduction demonstrate that hatcheries do provide the necessary protection during these critical periods. The publication by Mr. Hobbs on the natural reproduction of three species of salmonids in New Zealand contains much information essential for such comparisons with natural reproduction demonstrate that hatcheries do provide the necessary protection during these critical

periods. It must therefore be recognized as a most significant contribution to the theory of fish culture in particular and of fisheries management in general.

The introduction contains a brief survey of the statements and observations of earlier authors on the sources and extent of losses of salmonid eggs and fry in nature. In this section Mr. Hobbs took certain workers rather severely to task for speaking of "enormous" or "immense" losses of eggs and fry in nature without presenting actual quantitative data to support their remarks. He cited the recent work of Foerster as "the only thorough inquiry into losses in natural spawning-redds of any species of Salmonidae" that he had seen.

As to the work of Mr. Hobbs, himself--this review must unfortunately forego both the description of his painstaking and ingenious methods and the summarization of his interesting observations on spawning activities and behavior. Attention will be confined to his results as they pertain to the losses of eggs and fry in nature.

Losses outside the redds: Apparently all mature fish succeed in spawning since observations did not show that any fish in the streams be studied succumbed to natural causes before the extrusion of the ova.

Losses through the retention of eggs in the body cavity are insignificant. Twenty-two spent female salmon contained an average of only eight eggs and fourteen brown trout, an average of less than seven eggs. Such a complete removal of eggs by stripping would doubtless be considered reasonably efficient.

In a series of carefully conducted experiments Hobbs determined that "at least 97.5 percent of the eggs produced by brown trout lodge in the redds (nests) at the time of spawning." (There were no data for salmon and rainbow trout.) The almost complete spending and lodgement of eggs proves that losses outside the redds are negligible.

The non-fertilization loss: In brown trout, for which species the data were most complete, the percentage of fertilized eggs in the different redds ranged from 100 percent down to 97.73 percent, with an average of 99.17 percent. The percentage of fertilization of rainbow trout eggs was 99.43-99.82 percent. Quinnat salmon from one stream had a fertilization percentage of 99.21 and in another a percentage of at least 98.05 percent. On the whole, then, the losses from infertile eggs are not important.

Losses of fertilized ova: In general the losses of fertilized eggs exceed the losses of eggs through non-fertilization, but are still relatively small. The most vulnerable period in the life of the egg occurs in the pre-eyed stage. There is close correlation between losses and the dirtiness or abundance of fine material in the redds. The actual loss is probably occasioned by lack of oxygen.

In one salmon stream with normal undisturbed redds 97 percent of the eggs lodged in the redds hatched. Another stream which was affected by unusual adverse weather conditions had a hatch of only 76 percent.

Two brown trout streams had hatches in undisturbed redds of 95 and 97 percent. In a third stream the hatch was only approximately 75 percent and probably was less. This latter stream had very dirty redds.

The data on the rainbow trout were scanty but were held to be "not inconsistent" with results obtained from brown trout under similar circumstances.

The mortality of salmonid fry from the time of hatching until they leave the redds was found to be low.

Exceptional sources of loss: Floods may wash redds completely away, remove part of the surface material, leave redds stranded by changing the course of the stream, or injure them through the deposition of fine material. It was pointed out, however, that trout and salmon redds are usually found "in positions where they are least likely to suffer disturbance in flood time", and that in the New Zealand streams examined, "the only floods observed to alter redds substantially were abnormal, both in point of time and in point of volume."

The superimposition of redds of late spawners on those already made by other fish is a source of loss that may be severe if the spawning areas are very limited in relation to the number of fish. However, superimposition does not entail a complete loss of eggs in the earlier redds. One redd, for example, was found to contain eggs from two females; yet all the eggs were apparently in sound condition. At the other extreme was an area 12 by 3-1/2 feet which contained eggs from at least eleven different females; here the loss must have been heavy.

There was no evidence that predators caused any loss of either eggs or alevins (fry) in the redds. Neither was there any evidence that eggs were killed by being crushed. Eggs whose shape had been distorted by continued pressure were found to be perfectly healthy.

Conclusions: It is obvious from Mr. Hobbs' data that up to the time that the alevins leave the redds the natural reproduction of salmonids is normally extremely efficient, although exceptional conditions may occasionally bring about heavy losses. The critical period or time of high natural mortality must, therefore, occur after the alevins have deserted the redds.

Mr. Hobbs for some reason exercised the most extreme caution in the discussion of his results in relation to current practices in artificial propagation. In New Zealand wild fish are trapped and their eggs reared artificially and planted as fry. Nevertheless, Hobbs stated that his data "provide no ground either for recommending modifications of existing policy or for approving it." Later, on the same page, however, he spoke of the possibility that "the present system of fish-hatchery operations

in New Zealand safeguards the young over a period through which they are much less in need of protection than in an equal period of time immediately following their liberation." The latter of the two statements would appear to be the more valid.

Hobbs' data demonstrate rather conclusively that the artificial propagation f salmonids up to the advanced fry stage at which the young desert the redds offers little or no improvement on the processes of nature. Under favorable conditions 95 percent or more of the eggs spawned naturally in a redd will produce healthy, well-advanced fry. It is doubtful whether many hatcheries with well kept records can show a marked improvement over this figure. It is true, of course, that congested spawning grounds or exceptional conditions of flood may cause heavy losses in nature. On the other hand, it is not unknown in hatcheries for an accident (such as the contamination or failure of water supply) or an epidemic to produce heavy mortality of eggs and fry. The justification for the artificial propagation of salmonids must, therefore, lie entirely in the protection of the young after they have hatched.

Certainly Mr. Hobbs has done a great service in blasting the popular misconceptions that fertilization of salmonid eggs in nature is very inefficient and that "enormous" destruction of eggs and fry occurs in the redds. The striking results that he obtained suggest strongly the advisability of similar studies on the natural reproduction of other fish that are propagated artificially on a large scale.

Ralph Hile.

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